Research and Development Programme on ADS in JAEA

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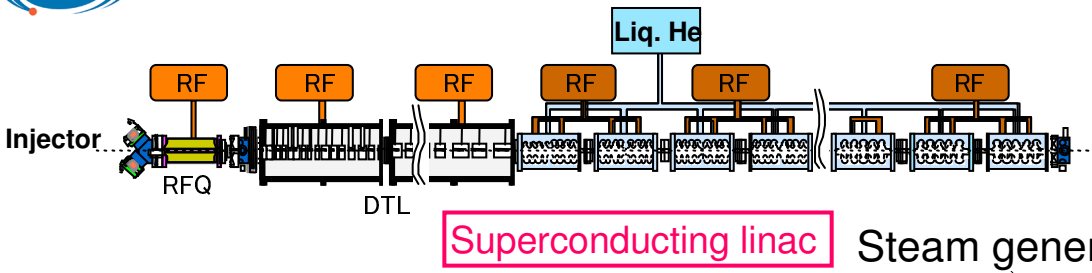
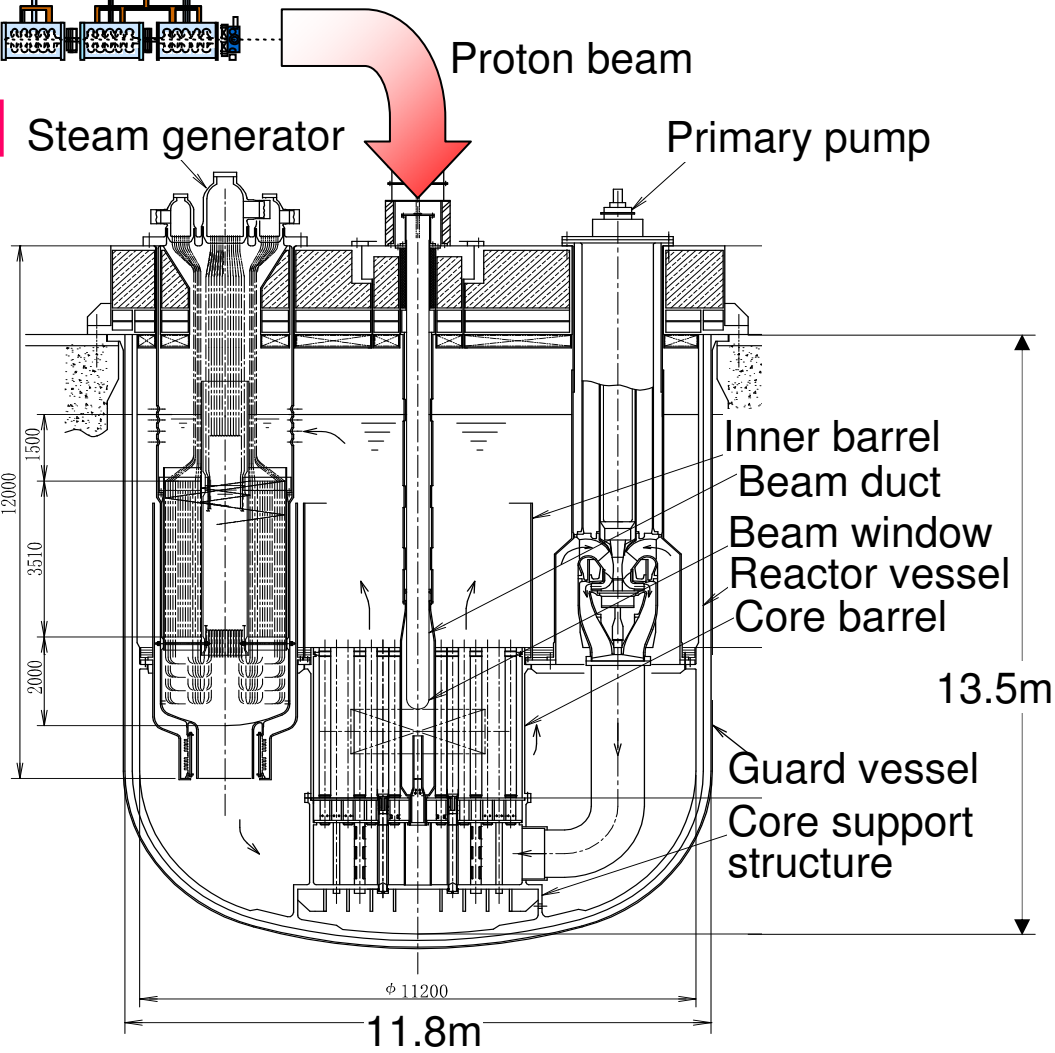
Conceptual Design *of Future ADS*





- Beam energy : 1.5 GeV
- Max. beam current : 20 mA
- Klystron : 972 MHz, 750 kW (cw)
- # of klystrons : 89
- Spallation target : Pb-Bi
- Coolant : Pb-Bi
- Max. k_{eff} = 0.97
- Thermal output : 800 MWt
- MA initial inventory : 2.5t
- Transmutation rate :
  10%MA / Year
- 600EFPD, 1 batch

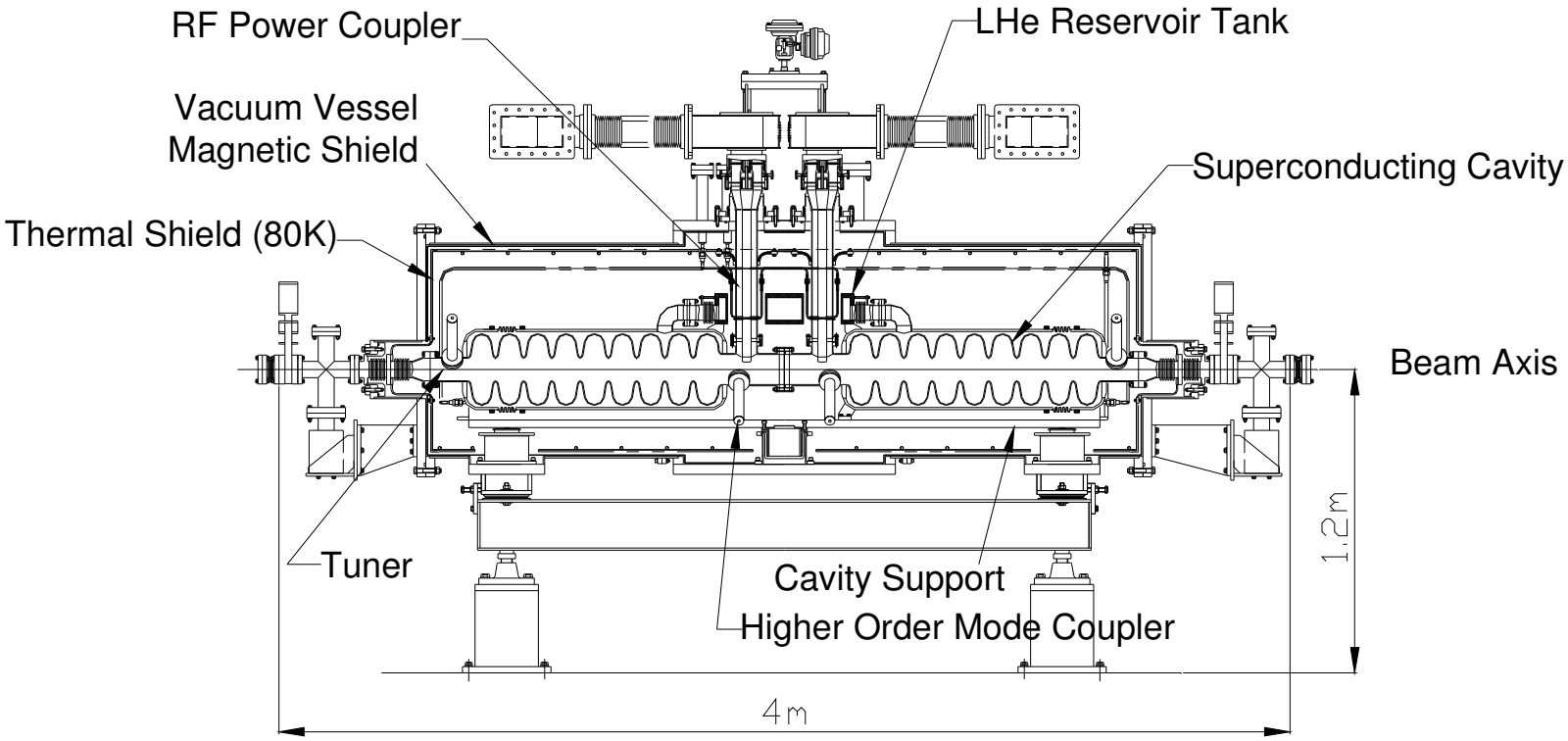
Feasibility Study on ADS in JAEA

- In JAEA, a comprehensive R&D program has been started.
- Items of R&D were concentrated on the **three technical areas** peculiar to the ADS:
  - A superconducting linear accelerator (**SC-Linac**),
    - ✓ Development of superconducting linac for ADS
    - ✓ Study on the reliability for a linac operation
  - A Pb-Bi (**LBE**, lead-bismuth eutectic) as a spallation target and core coolant [1],
  - **Subcritical core design and reactor physics** of the ADS [1].

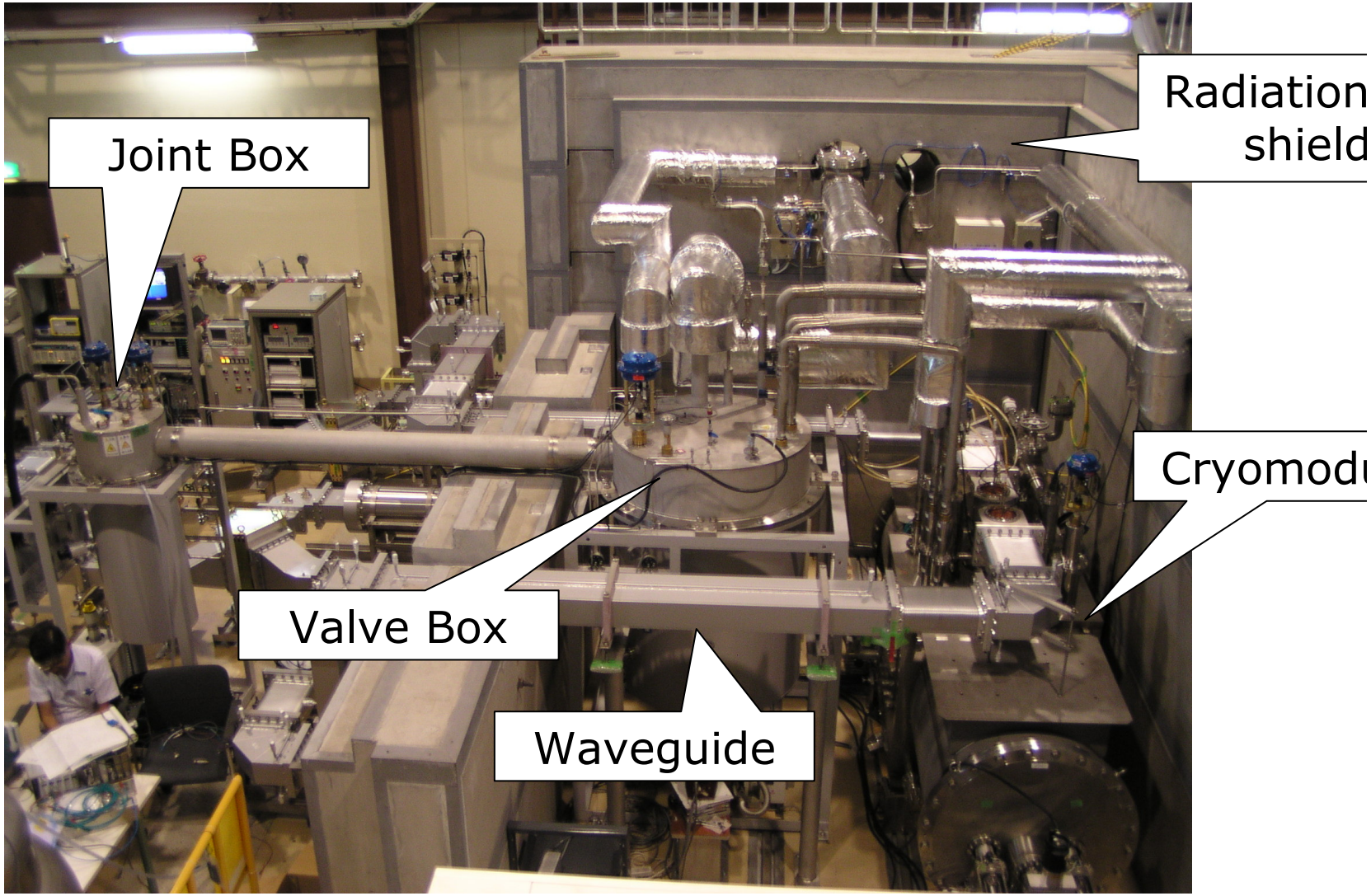
[1] TSUJIMOTO, K., et al., “Feasibility of Lead-Bismuth-Cooled Accelerator-Driven System for Minor-Actinide Transmutation”, Nuclear Technology, 161, (2008) 315-328.

SC Linac development (1) Cryomodule Design

- Two 9-cell elliptical cavities of β=0.725 at 2 K (972 MHz)
- A coaxial type power coupler (Cu) and two HOM coupler (Nb and Cu)
- 80 K thermal shield by LN_2 and 5K thermal intercept by LHe

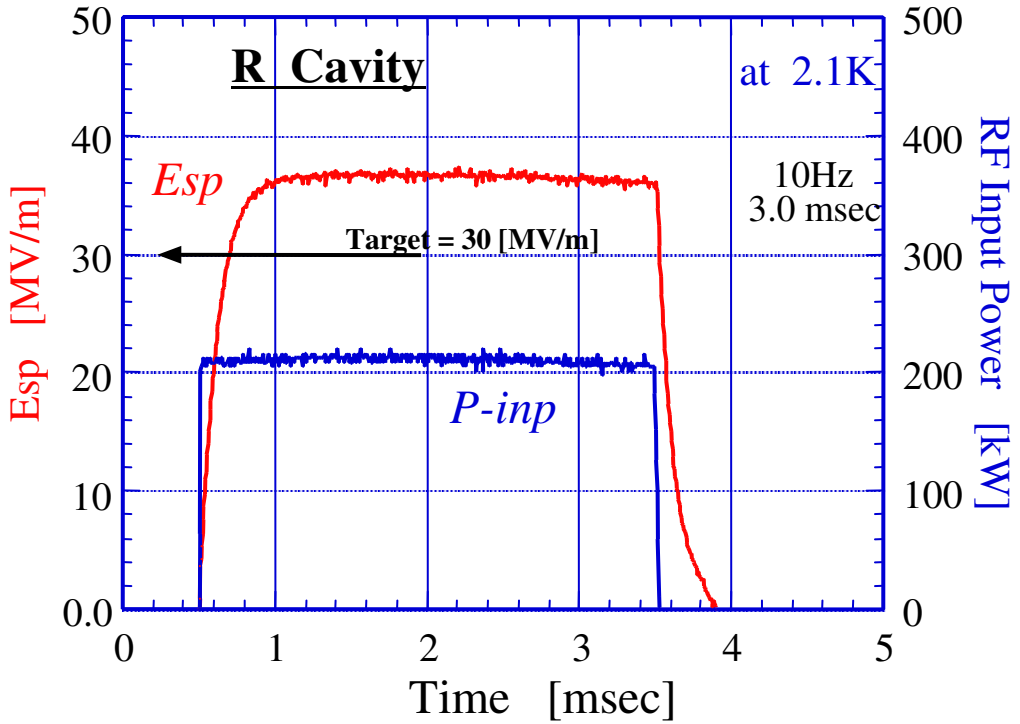


SC Linac development (2) Experiment



SC Linac development (3) Experimental Results

- **RF Properties**
  Surface peak Field (Esp)
  37, 35 MV/m
  (Target 30 MV/m)
  at duty factor of 3%



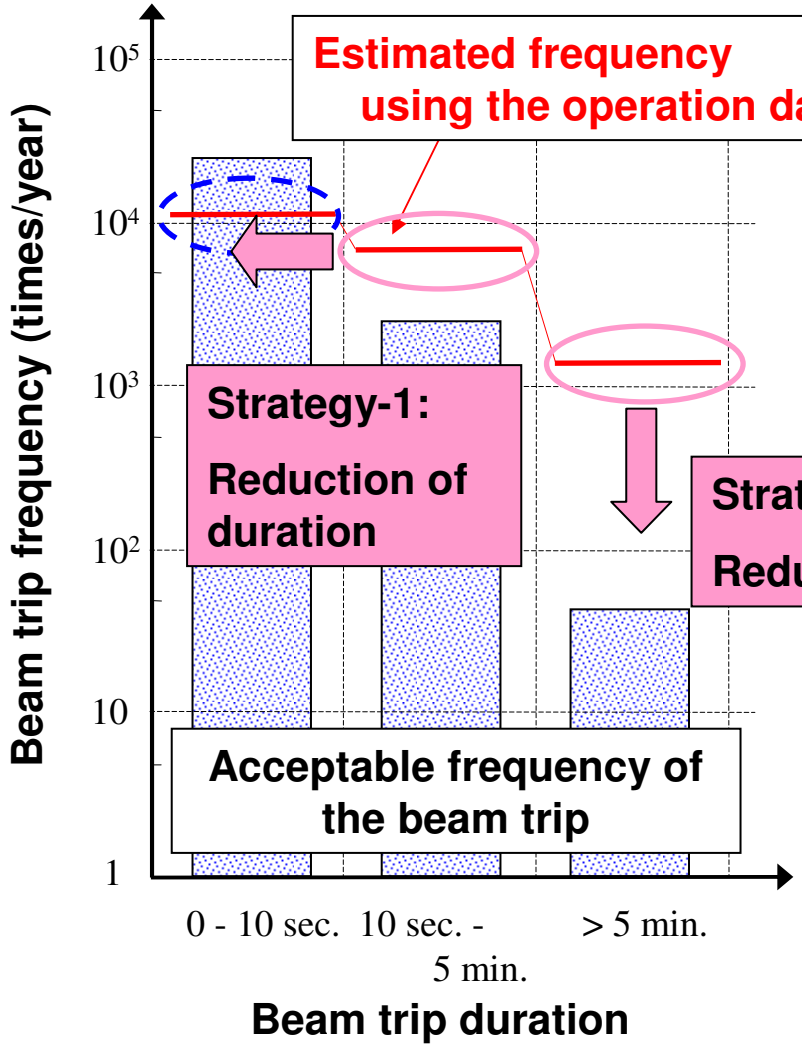
- Higher duty factor operation is limited up to 3% due to poor cryogenic performance.
- These results provided prospects for realization of practical cryomodules.

Study on the reliability of SC-linac

- Frequent beam trips may cause thermal fatigue problems in ADS components which may lead to degradation of their structural integrity and reduction of their lifetime.
- **Influence** for the thermal shock damage on **the ADS reactor system** caused by beam trips has **not** been **evaluated sufficiently**.
- Conversely, it is **not yet clear** how often the ADS reactor system can accept for the beam trips.

- The purpose of the present study is to know the present level of accelerator technology by comparing beam trip frequencies estimated from operation data of existing accelerators and the requirement from transient analyses of the ADS reactor system.

Study on the reliability of SC-linac
- Comparison of beam trip frequencies -

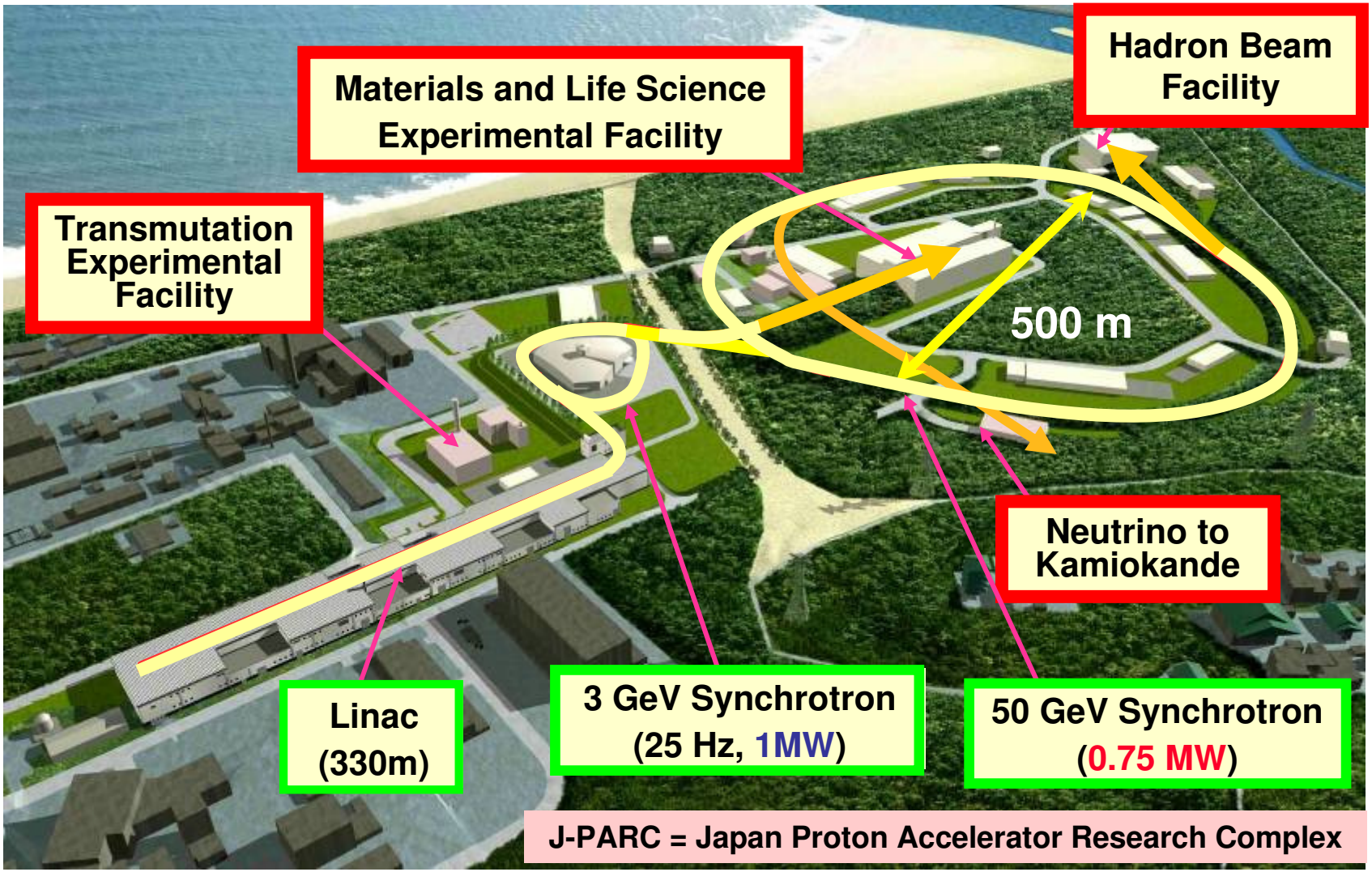


- N_{inj} ~ **9,000** times/year (LANSCE)
- N_{rf} ~ **12,000** times/year (KEKB linac)

- The beam trip frequency (***T* < 10 sec.**) is within the **acceptable value** at the **present level** of accelerator technology.

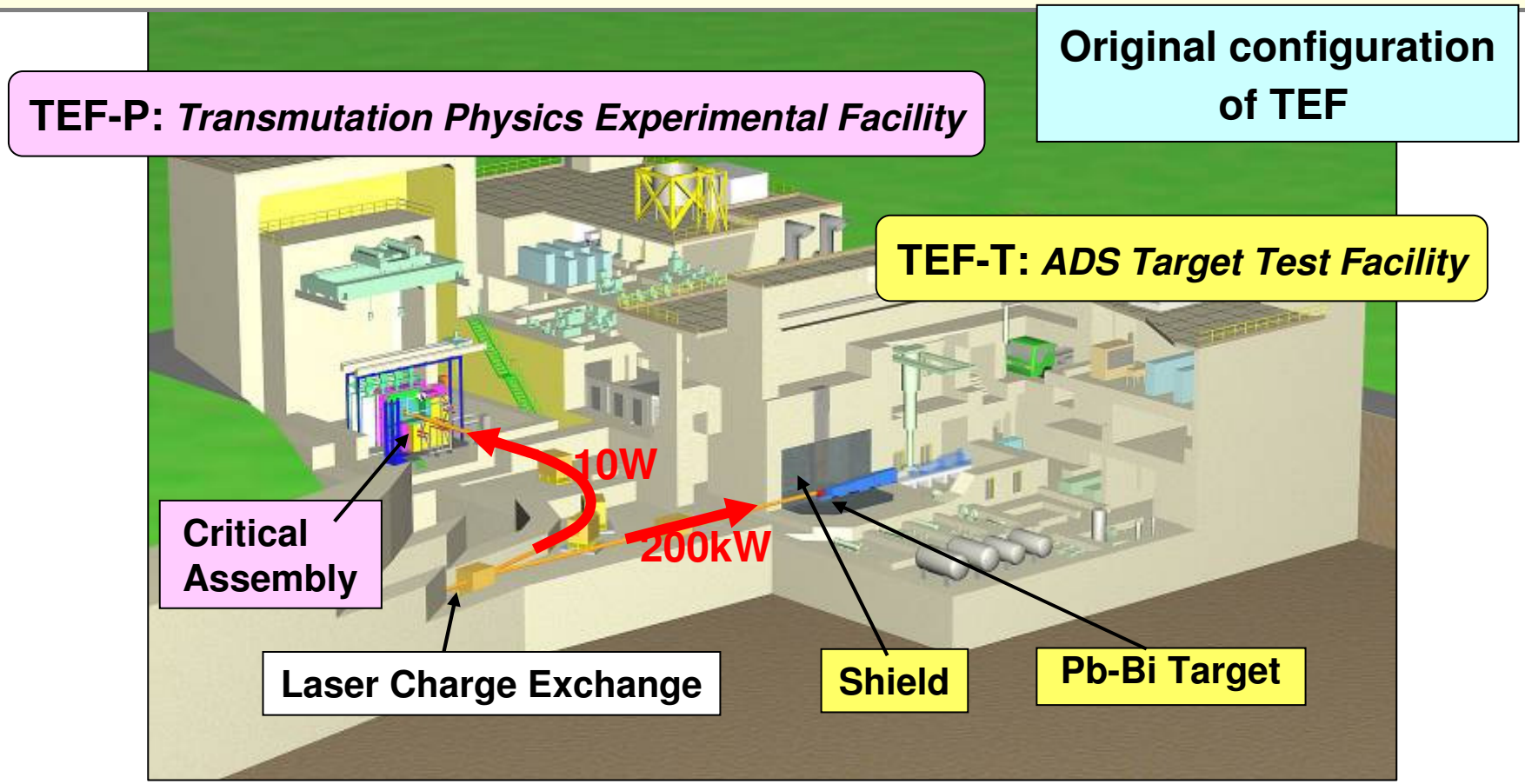
- Details will be discussed in this meeting (ADS/P4-06)

Current Status of J-PARC Project: Site Plan



Original Configuration of Transmutation Experimental Facility

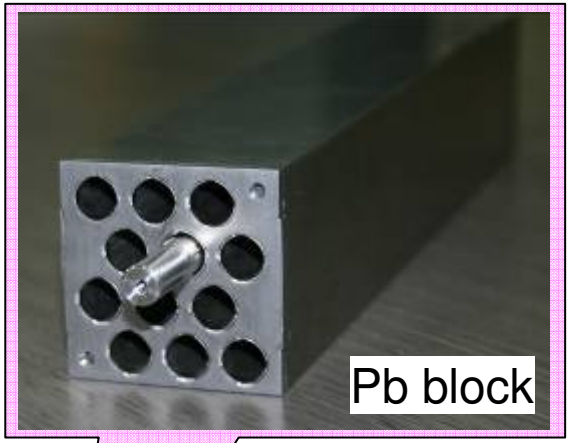
- Transmutation Experimental Facility (TEF) : Phase-2 Program.
- Original configuration of TEF consists of the Transmutation Physics Experimental Facility (TEF-P) and the ADS Target Test Facility (TEF-T).
- Because of the budget shortage, step by step construction will be necessary.



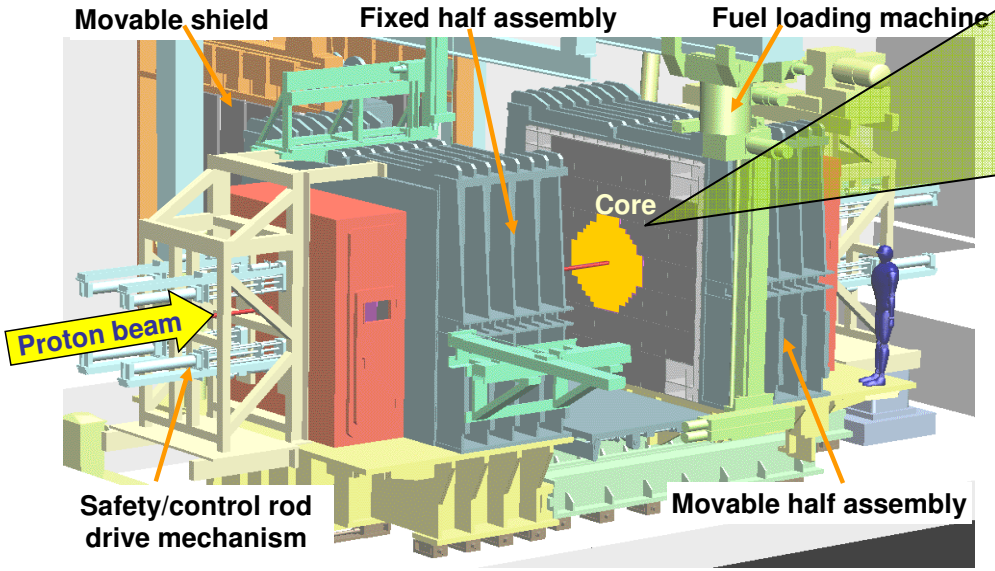
Current status of facility site

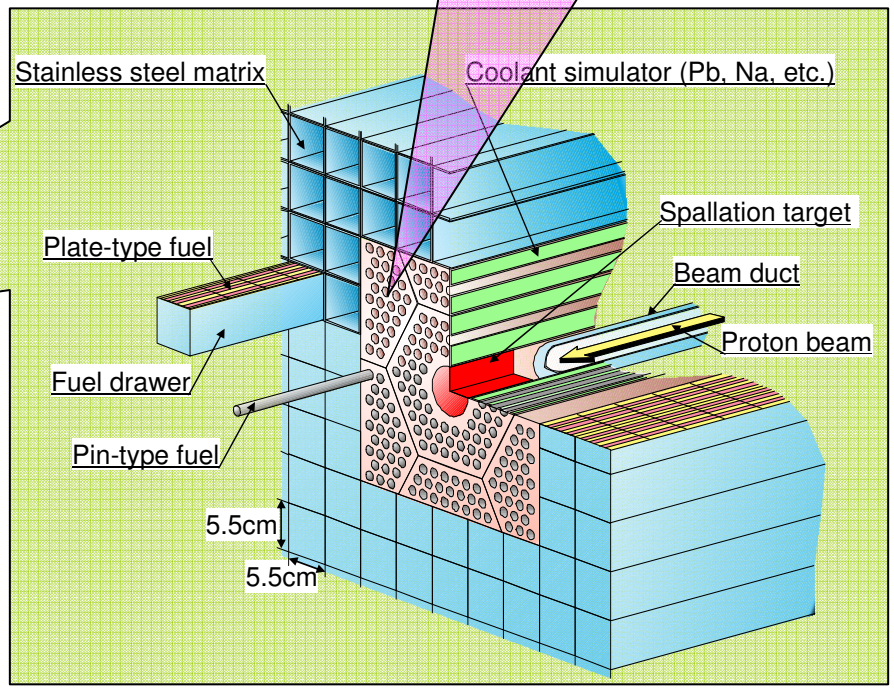
Outline of TEF-P

- **Critical facility** for reactor physics and nuclear data of transmutation systems: both ADS and FBR.
- Neutron source: **10^{12}n/s**, 25Hz. 1ns pulsed beam is available by laser charge exchange technique.
- **Pin-type MA fuel can be used** with appropriate cooling and remote handling.



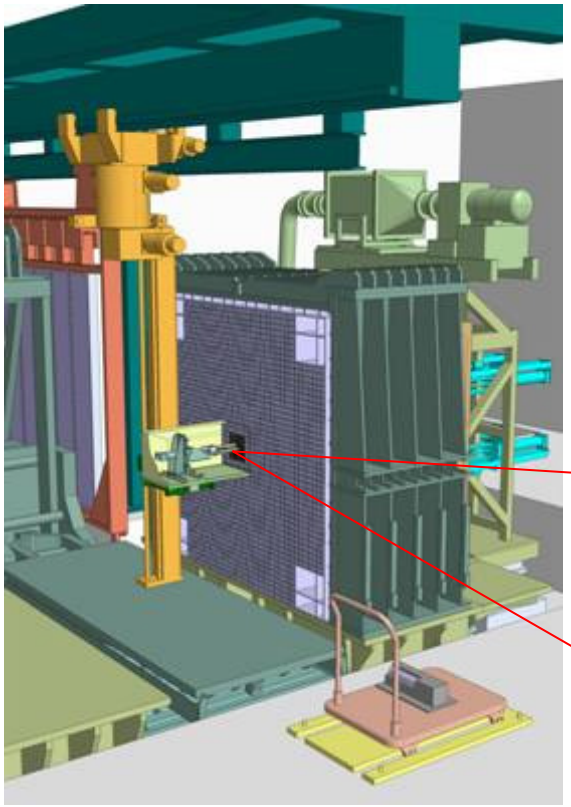
Maximum thermal power : 500W

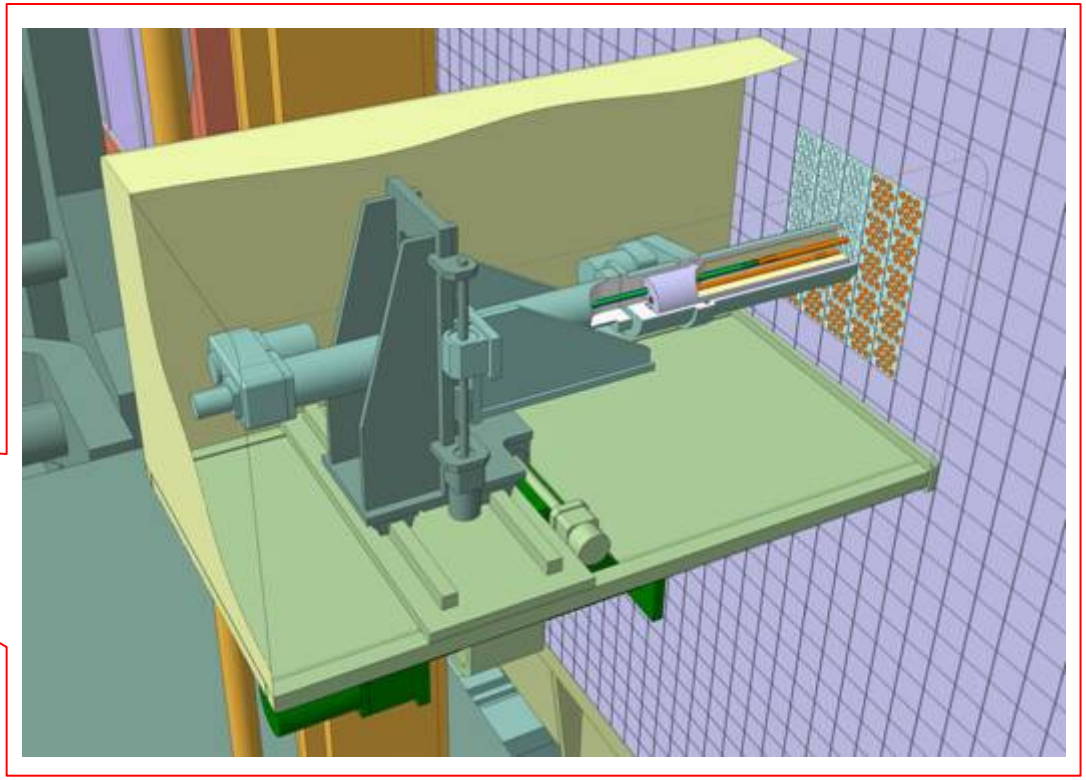




Application of MA-bearing Fuel in TEF-P

- MA-fuel is stored in cylindrical cartridge to prevent gamma and neutron exposure and critical accident.
- Remote handling device is required for storage / transport / loading of MA-fuel.
- Constant cooling by forced air is required for MA-loaded zone in the core.
- Air-conditioning is required for MA storage rooms.





Call for Preliminary Letters of Intent (LOI) for TEF

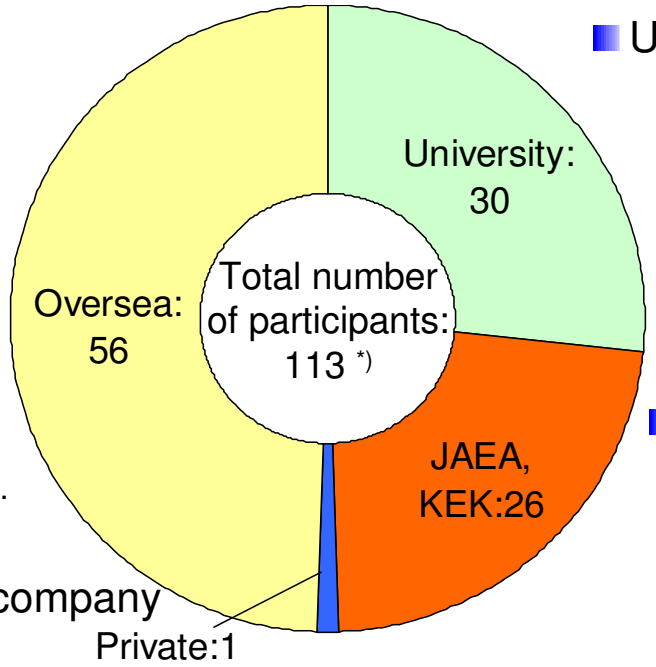
- The project team called for the ***Preliminary Letters Of Intent (Pre-LOI)*** for TEF.
- Purposes:
  - To know which groups have an interest in this activity
  - To reflect the proposals on the specifications and layout of the TEF
  - To establish an appropriate collaboration scheme between J-PARC and the anticipated outside users.

Results of Preliminary Letters Of Intent for TEF

- **Total number of received Pre-LOI : 37**
- Areas
  1. Reactor physics of ADS: 11
  2. Reactor physics of advances nuclear system including MA-loaded experiments: 10
  3. Nuclear data and neutron spectrum measurements: 6
  4. High-energy physics, shielding: 5
  5. Nuclear physics (neutrino measurement, ultra cold neutron): 2
  6. Pb-Bi spallation target: 2
  7. Boron Neutron Capture Therapy: 1

- Oversea
  - EUROTRANS
  - PSI (Switzerland)
  - CIAE (China)
  - Seoul National Univ. (ROK)
  - MINT (Malaysia)
  - NTI (Serbia)

  *) Number of participants from EUROTRANS is not included.
- Private
  - Japanese engineering company



- University
  - Hokkaido
  - TIT
  - Nagoya
  - Kyoto
  - Kyushu
  - Tohoku
  - Niigata
  - Osaka
  - Kinki
- JAEA & KEK
  - Quantum Beam Science
  - Nuclear Science & Engineering
  - Advanced Nuclear System
  - J-PARC Center

Check & review of the partitioning and transmutation technology

- The Atomic Energy Commission (AEC) started the check and review of partitioning and transmutation (P&T) technology from September, 2008.
- Nine meetings were convened until March, 2009, and the final report reflecting public comments was issued.
- **Purposes**
  - To illustrate the benefit and significance of P&T
  - To review current state of the art concerning P&T technology in Japan
  - To discuss how to conduct future R&D

Check & review of P&T
- Discussion Issues -

- Significance of P&T
  - Benefit and cost, and introduction scenario
  - Variation of transmutation system (Homogeneous / Heterogeneous, FR / ADS)
- Current State of the Art
  - Status of R&D for P&T including those of overseas
  - Review of studies performed by JAEA and CRIEPI
  - Current Status of J-PARC Transmutation Experimental Facility
- Future R&D
  - Direction of R&D
  - Organizing different concepts (Homogeneous / Heterogeneous / dedicated)
  - Requirements for future infrastructures
  - Application of international cooperation

Check & review of P&T
- Recommendations by AEC (1) -

Descriptions in the report:

- Basic Policy on P&T
  - R&D on P&T should be linked strongly with that of FBR cycle. It means the R&D should NOT aim at the improvement of the P&T performance, BUT at the achievement of the whole performance including safety, economy, environmental-friendliness, saving resource, and non-proliferation.
  - The basic data to judge the feasibility of P&T are insufficient. It is, therefore, necessary to continue the accumulation of the basic data which are commonly utilized for both FBR and ADS.
  - Double-strata concept should be studied as a part of the whole nuclear system both in the transient phase of LWR to FBR and the equilibrium state of FBR.
  - R&D of FBR and ADS should be coordinated strongly and their periodic evaluation is required.
- R&D issues on ADS are as follows:
  - Accelerator with sufficient economy and reliability.
  - Feasibility of the beam window.
  - Reactor physics of subcritical core including its control.
  - Design and safety of the LBE core.
  - Feasibility of MA nitride fuel and its dry reprocessing.

Check & review of P&T
- Recommendations by AEC (2) -

Descriptions in the report:

- R&D on transmutation system
  - For both FBR and ADS containing certain amount of MA, the nuclear data preparation is essential issue to ensure the safety and the economy of the transmutation systems.
  - Integral validation of MA nuclear data by critical experiments using MA bearing fuel , including J-PARC Transmutation Physics Experimental Facility (TEF-P), should be discussed.
  - The R&D on ADS should be promoted on the basis of collaboration with the activities overseas, the R&D on spallation neutron sources, and the R&D on FBRs.
  - As for the feasibility of coupling of subcritical core with a proton accelerator, J-PARC Transmutation Experimental Facility is expected to play an important role. Judgment of its construction should be discussed considering the results of FFAG-KUCAR experiment.
- Future Evaluation:
  - Next Check and Review will be carried out in 2010, which is the opportunity to discuss the roadmap of FBR and the next-generation reprocessing plant in Japan.

Concluding Remarks

- As for the technical development of SC-Linac, fabrication and tests of prototype cryomodule were carried out, and its good performance was demonstrated.
- The reliability of the accelerator is being investigated based on the data analysis of existing linac facilities. Reduction of frequency for relatively long beam trips is important to overcome this trip problem on ADS.

- The approval to start construction of the TEF has not yet been decided by the Government.
- Since September 2008, the check and review of the P&T technology has been implemented by the AEC of Japan.
- As for recommended by AEC, JAEA will make its best efforts to basic studies for physics properties of MA-loaded systems (both Fast Reactor and ADS).